ARTICLE IN PRESS

ISA Transactions xxx (xxxx) xxx

Contents lists available at ScienceDirect

ISA Transactions

journal homepage: www.elsevier.com/locate/isatrans

Research article

Experimental investigation of efficient and simple wind-turbine based on DFIG-direct power control using LCL-filter for stand-alone mode

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ARTICLE INFO

Article history:
Received 29 June 2020
Received in revised form 19 June 2021
Accepted 4 July 2021
Available online xxxx

Keywords:
Wind Energy Conversion System: WECS
Direct Power Control: DPC
LCL-Filter
dSPACE 1103
Doubly Fed Induction Generator: DFIG
Integral-Proportional: IP

ABSTRACT

This paper suggests an experimental implementation study of the Wind Energy Conversion System (WECS) based on efficient Direct Power Control (DPC). Stand-alone mode for variable wind speed application using Doubly-Fed Induction Generator (DFIG) is studied and developed in this work. Due to the wind power performance limitation of traditional PI controllers, such as overshoot, response time, and static error; IP (Integral–Proportional) controllers is replaced instead of the PI to control rotor current d–q components (I_{rd} and I_{rq}) in a Park frame through AC–DC–AC converter. A comparative experimental study was implemented to improve the power quality using L, LC & LCL passive filters between the DFIG's rotor circuit and the inverter. Experimental results prove that the proposed DPC under stand-alone mode with LCL-Type filter could operate in several conditions despite the sudden wind speed variations. It improves the unity power factor grid operation (≈0.98), dynamic responses, and the decoupled power control with high wind power performances: good reference tracking, short response time, neglected overshoot, and low power error. The power quality injected into the RL-load satisfied the limit specified by IEEE harmonic standard 519 (less than 5%).

1. Introduction

Wind power potential has been rising massively in the recent years, with new plants by 2050, capacity of 5044 (GW) for on-shore wind turbines and capacity of 1000 (GW) for offshore wind turbines [1]. Wind power generation is considered as one of the most efficient alternative sources of electricity due to its economic advent ages [2]. For a variable speed wind turbine (VSWT), there are multiple benefits to the use of a double-fed induction generator (DFIG), such as decreased noise, lower mechanical stress on the wind generator shaft, scaled-down inverters, and the ability to regulate stator active and reactive power [3,4]. The principal gain is that the power converter is rated at only 25%–30% of the generator power (Fig. 1), which reduces the price of the converter and the power losses [5,6]. It also permits control of reactive and active power. The power electronics became a lot of advanced with the increasing capability coverage, and have brought important performance enhancements to wind turbines (WTs); not solely increasing energy and reducing mechanical stress [7], but also by allowing the WTS to operate as a more flexible controllable generator for incorporation into electrical networks.

The major AC power generation-based DFIG control topologies for both grid-connected [8,9] and stand-alone [10,11] systems are largely provided in the existing research literature (please refer Fig. 1). The following are the more popular control approaches, for the control of DFIGs, field-oriented control (FOC) through stator flux based, and Direct Power Control (DPC). In [12,13], DPC is known for its fast time-to-response, easy structure, and less parameter reliance, which has attracted a wide range of academic and industrial communities.

In [14], the authors have studied a novel algorithm for DC-voltage tuning. The basic idea of this research focused on the adjustment of the DC link voltage is carried out by means of the stator voltage magnitudes control through a d-axis rotor current of the flux control loop in a Park frame. The load current will be immediately assisted by the q-axis rotor current.

In [15], the authors suggested an interest search called "sensorless frequency and voltage control" in autonomous mode. The basic goal of this paper was to minimize the number of detectors and the detectorless realization was adopted to achieve the field orientation and adjust DC-voltage and the stator frequency.

In [16], the authors proposed a new study to analyze an autonomous DFIG system and the DC voltage control with sensors reduction. The aim of this search is a redesigned regulation

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https://doi.org/10.1016/j.isatra.2021.07.008
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Please cite this article as: F. Amrane, B. Francois and A. Chaiba, Experimental investigation of efficient and simple wind-turbine based on DFIG-direct power control using LCL-filter for stand-alone mode. ISA Transactions (2021), https://doi.org/10.1016/j.isatra.2021.07.008.